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Reducing water pollution risks by wash water from water treatment plants

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Abstract: The article analyses chemical methods to treat washwater from rapid filters at surface water treatment plants. The review of existing approaches to the application of rapid filter washwater is carried out. During the research work washwater from rapid filters was chemically treated with coagulant "Bopak-E", flocculants "Praestol", and sorbent-coprecipitant reagent "Ecosol-401". The doses of reagents were selected and the efficiency of water purification from turbidity and chromaticity was shown. The proposed technology of washwater treatment allows to obtain drinking quality water after sedimentation and filtering.

1. Introduction

Issues of protection of natural waters from pollution are becoming increasingly urgent nowadays. Currently, as a rule, facilities with two or three-stage technological process are designed for their purification. The operation of such facilities requires a large number of reagents and a significant water consumption for their own needs. Treatment of waste water from sedimentation tanks, filters, clarifiers with a layer of suspended sediment, contact clarifiers and reagent facilities in compliance with the rules of protection of surface sources from pollution can reduce the lost volume and the negative impact on water bodies.

The washwater from the waterworks contains almost all the impurities of the source of water supply and detained during the clarification of natural water. It also includes reagents introduced during the purification of natural water, and with a concentration much greater than the dose in the treatment of water.

Considering the problem of treatment of washwater among the many general issues of water resources protection, it should be noted that it remains one of the least developed, the most technically complex and expensive ones. A successful solution of this problem requires the study of the composition, structure and properties of waste water, the possibility of changing the initial properties of washwater, as well as the determination of optimal parameters of the technological processes that ensure the treatment of washwater of different initial quality [1].

There are several main areas in washwater treatment:

- the supply of the washwater into a pipeline mixer before purifying in the tank-neutralizer, directly into the mixer after precipitating in the mixer after special treatment;
- the discharge of the washwater in the sewage system with subsequent supply to the sewage treatment stations;
- the discharge of the washwater without treatment into the reservoir or to specially designated areas of terrain (without purification) [2].



It is technologically and economically feasible to separate the washwater of the filter facilities from the main water treatment process and use them after purification for another purpose, for example, for washing of filters. However, it is recommended to wash the rapid filters with filtered water. Thus, the quality of washwater used for repeated washing of filters should correspond to the quality of purified natural water [3]. This creates the need to find effective technologies for the treatment of washwater, including reagent.

2. Existing solutions to the recycling of washwater

Taking into account a huge volume of discharges (5-15% of the total capacity of water stations) and consumed reagents, the problem of treatment and reuse of waste water requires an immediate solution [4].

For the purpose of rational use of water and protection of the environment in water treatment plants, it is recommended to reuse water after washing rapid filters and contact purifiers. Clarified water above the sludge can also be reused in technical sedimentation tanks and washwater sedimentation tanks, thickeners, sludge storage, and dewatering sites. It should be noted that there is a need for technological analysis and justification of the re-use of washwater filter facilities in each case. The need for careful justification of reuse of wash water is due to a significant difference in the quality of the source water and, accordingly, the complexity of the technology of water preparation, which can lead to a disruption of natural water purification regimes and deterioration of the quality of treated water [4].

The circulation of wash water from rapid filters, i.e. the establishment of a system of reuse washwater (SRUWW) from rapid filters, both in the past and in the present is developing in several directions.

The first direction is **"the supply to the head of treatment facilities of washwater without water precipitation"** from the intermediate tank (actually performing the function of the neutralizing agent). As a result, the interval between water discharge and the beginning of its supply from the neutralizing tank is reduced to a minimum and the accumulation of the bulk of the sediment is ensured only in sedimentation structures. In addition, the introduction of coagulated suspension into the source water occurs during the supply of undiluted water, which should improve the process of coagulation and sedimentation, especially at low initial values of turbidity.

Studies conducted at the Department of "Water Supply and Sewage Disposal" of Rostov State Construction University (RGCU) indicate that with the introduction of 15% washwater of the main flow rate, there is no deterioration in the quality of purification of the source water, and the increase in doses of the reagents used is not required.

Despite the advantages mentioned, according to the authors, there are some concerns in the application of this method, e.g. the variability of the quality of washwater supplied to the head of the facilities, and the need to maintain impurities in the suspended state [5].

The second direction is **"the supply to the head of treatment facilities with preliminary sedimentation."** The use of sedimentation (reagent-free or with the use of reagents) in the neutralizing tank or in a separate sedimentary basin makes it possible to obtain the discharge water of constant quality, supplied with a constant flow rate. As a result, the main facilities operate in a stable mode, both in terms of consumption and increase in the content of suspended solids due to the addition of waste water. Adding reagents to the waste water and using mixing systems (this requires much less power than in maintaining impurities in suspension) allow to vary the water quality at the outlet of SRUWW and to ensure a narrower range of fluctuations of the quality indicators throughout the seasons of the year. In addition, it is necessary to specify possible variation of a place of supply of the cleared washwater to the basic process depending on the change of its quality and peculiarities of the basic constructions [6].

The third direction is **"the treatment of waste water to the required quality** (drinking, for washing filters, watering, etc.) **with subsequent use"** and can be considered as the development of the second direction. Water after the sedimentation basin (neutralizing tank) is sent for further purification

(mainly filters) or to the object of consumption based on the quality of the precipitated water. In this case, the flow rate from water intake facilities is not reduced and there is no impact of waste water on the main flow, but there are additional volumes of water that can be used for appropriate purposes with a certain economic return.

The fourth direction of the development is "**the combination of methods**", i.e. a synthesis of the directions discussed above, which is designed to take into account economic, technological and other factors to optimize the operation of water treatment facilities in general and the system of reuse of washwater from rapid filters, in particular.

The authors have studied the washwater of the Western filtration plant in Ekaterinburg and investigated the treatment methods of water in the second and third directions.

3. Results of the experiment

In the course of the research, the quality indicators of wash water from rapid filters were determined: turbidity is 44.2 mg/dm^3 ; chromaticity is 23 degrees and hydrogen index is 7.6. This washwater is practically not precipitated, median fall diameter below 0.1 mm/s . To purify this washwater, the reagent aluminium oxychloride of the "BOPAK-E" brand was tested. This coagulant has a number of advantages over other aluminum-containing coagulants and is widely introduced into the waterworks system of the Sverdlovsk region [7].

The results of washwater treatment with this coagulant are presented in Figures 1 and 2.

As shown in Fig.1 and 2, during the experiments it was found that the optimal dose of aluminum oxychloride coagulant required for the treatment of rapid filter washwater is 3 mg/dm^3 of Al_2O_3 , thus a further increase in the dose is impractical. To intensify the coagulation process flocculants "Praestol" were tested being introduced after the coagulant.

The experimental results are shown in Figures 3 and 4

Figures 3 and 4 demonstrate that anionic flocculant Pr-2540 proves to be the most effective one. Its efficiency reaches 96% at a dose of 1 mg/dm^3 .

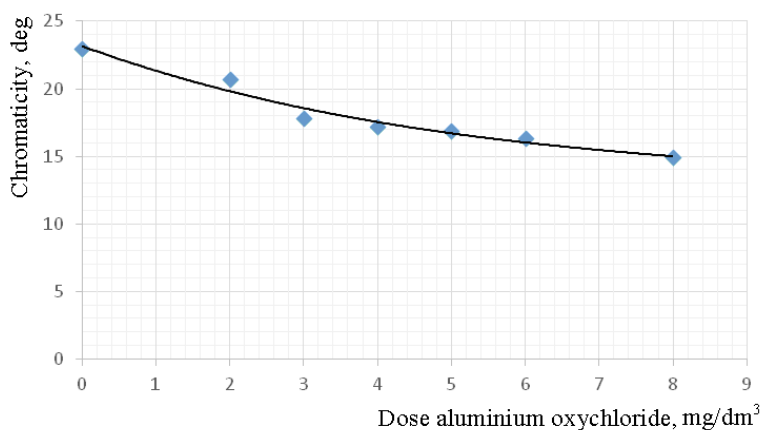


Figure 1. The impact of aluminium oxychloride on chromaticity of cleared water

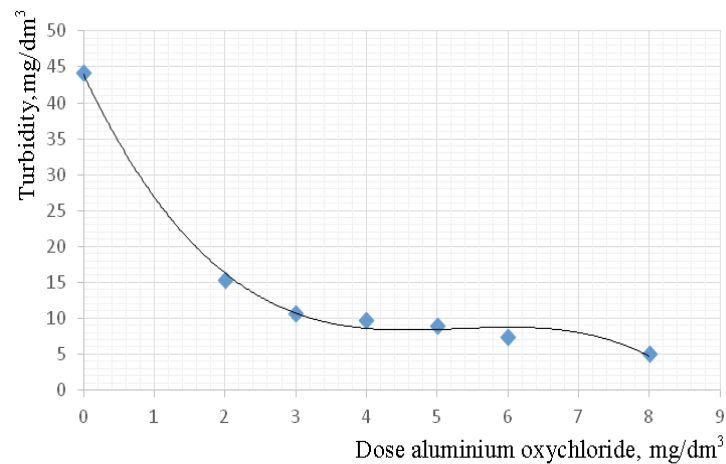


Figure 2. The impact of aluminium oxychloride on the turbidity of the cleared water

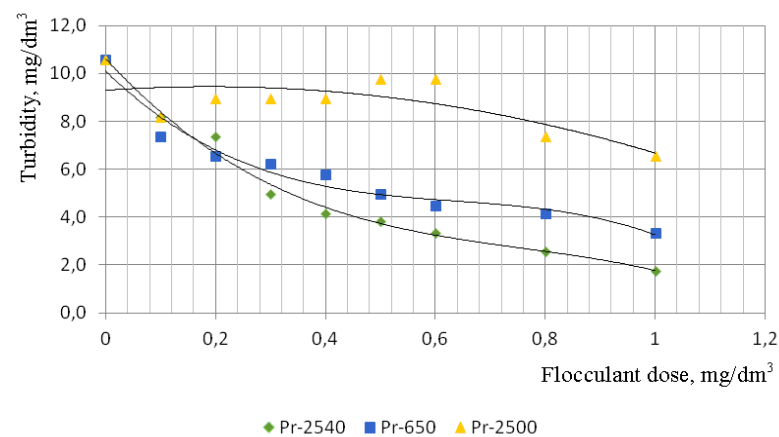


Figure 3. The impact of flocculant dose on turbidity of cleared water (the coagulant dose of 3 mg/dm³ of Al₂O₃)

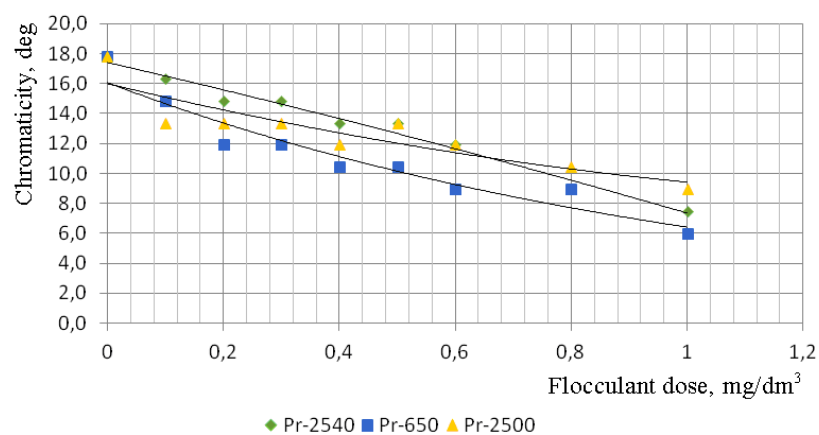


Figure 4. The impact of flocculant dose on the colour of cleared water (the coagulant dose of 3 mg/dm³ of Al₂O₃)

The introduction of flocculant leads to the intensification of coagulation, the reduction of turbidity, chromaticity and the increase of the effect of clarification, but there is a low rate of deposition of particles. To improve hydraulic size, a decision was made to introduce additional reagent "Ecosol-401" [8]. The dose of this reagent was taken as 50 mg/dm^3 . The results of the experiment are shown in Figure 5.

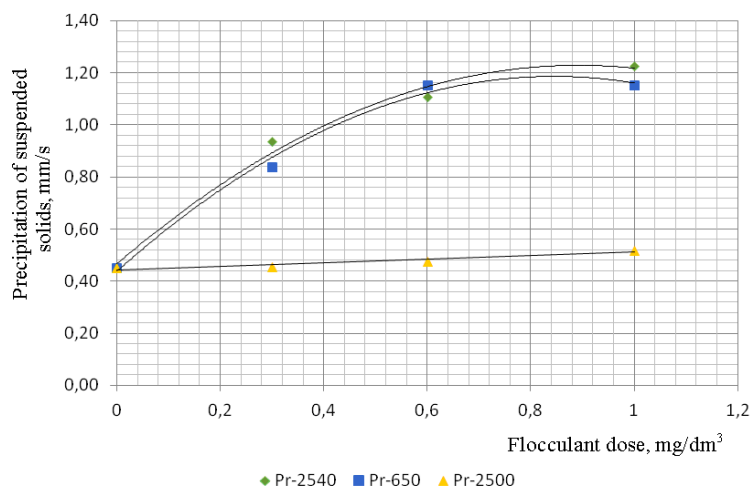


Figure 5. The impact of flocculant dose on precipitation of suspended solids (aluminium oxychloride dose is 3 mg/dm^3 ; "Ecosol-401" dose is 50 mg/dm^3)

The graph shows that the hydraulic size for the cationic and anionic flocculant is almost the same, and it increases with the increasing dose. The increase of the doses of non-ionic flocculant made little impact on the hydraulic particle size, its change is negligible.

4. Conclusions

Through the research we carried out chemical treatment of the washwater from rapid filters with coagulant "Bopak-E", flocculants "Praestol" reagent and sorbent-coprecipitant "Ecosol-401".

In the first series of experiments, the quality indicators of washwater from rapid filter were determined to be 44.2 mg/dm^3 for turbidity, 23 degrees for chromaticity and 7.6 for hydrogen index, respectively.

In the second series of experiments, we found the optimum dose of coagulant aluminum oxychloride "Bopak-E" required for treatment of washwater from rapid filters, which equals 3 mg/dm^3 of Al_2O_3 . With the introduction of this dose of coagulant there is a decrease in turbidity to 10 mg/dm^3 and chromaticity to 16. The clarifying effect reaches 76%. The decrease in pH is insignificant.

At the last stage of the work, the type and optimal dose of the flocculant "Praestol" was determined. The best effect of clarification was observed with the introduction of anionic flocculant Pr-2540, the optimal dose of which was 0.6 mg/dm^3 . The indicator of the quality of the clarified water turbidity was 3.4 mg/dm^3 and that of chromaticity was 9 degrees.

To increase the speed of flocculation and sedimentation, we introduced the "Ecosol-401" reagent in the amount of 50 mg/dm^3 . After its introduction, the hydraulic size increased to 1.11 mm/s .

The proposed technology of washwater treatment allows obtaining drinking quality water after sedimentation and filtering.

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